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Wheeler et al.

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(54) **FLUID PREHEATER**

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(73) Assignee: **Nexthermal Corporation**, Battle Creek, MI (US)

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(51) **Int. Cl.**
F24H 1/18 (2006.01)

(52) **U.S. Cl.**
USPC **392/450**; 392/441; 392/449; 392/494

(58) **Field of Classification Search**
None
See application file for complete search history.

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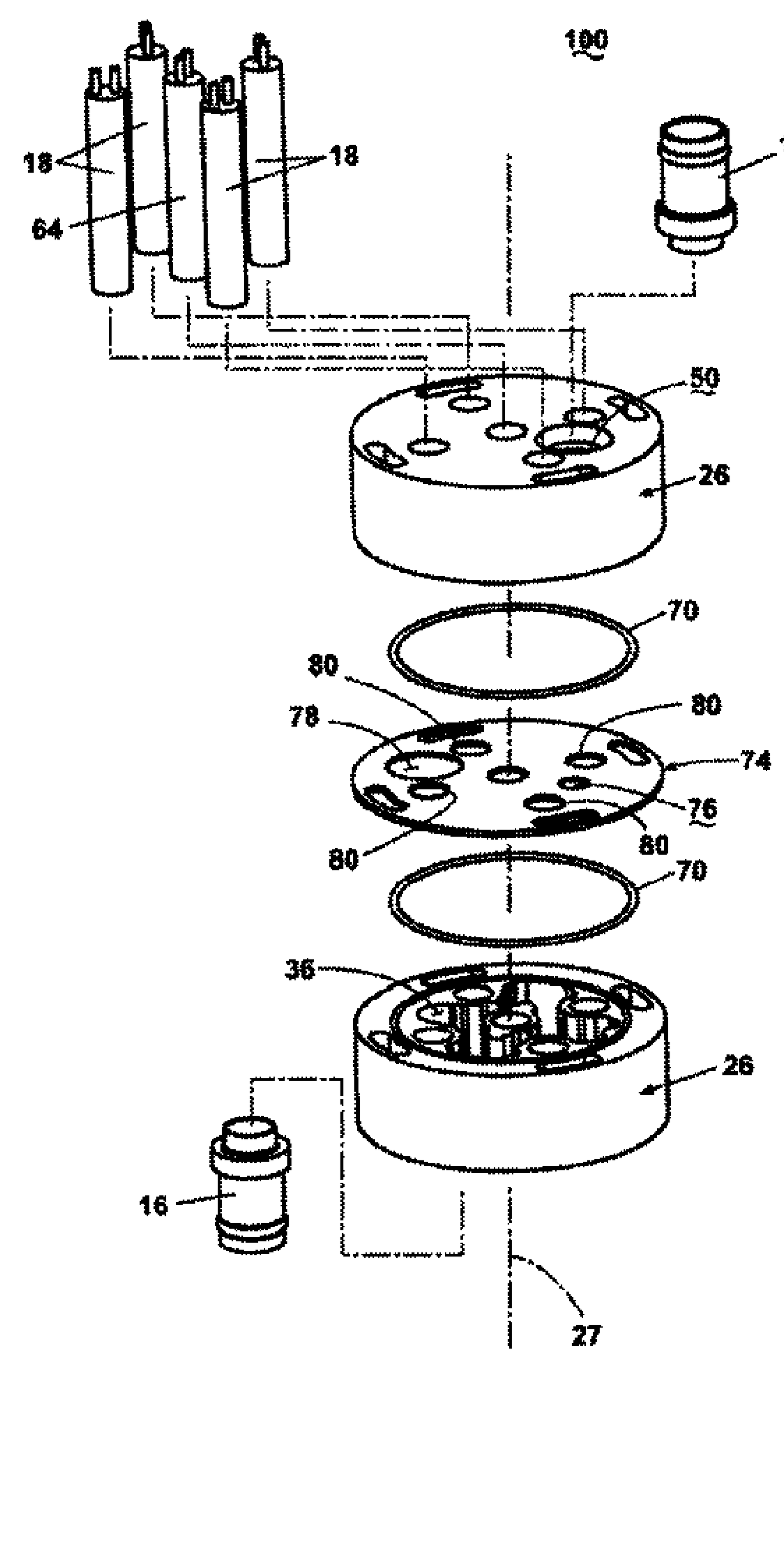
(57) **ABSTRACT**

A fluid preheater (**10**) includes a body (**12**) having an interior wall (**28**) defining a chamber (**42**) and having an inlet (**50**) and an outlet (**52**). One or more heaters (**18**) are disposed in the wall (**28**), but not exposed to the chamber (**42**). The chamber (**42**) has one or more baffles that cause turbulence in the flow of fluid through the chamber (**42**) from the inlet (**50**) to the outlet (**52**) in order to increase the exposure of the fluid to heat from the heaters (**18**, **64**).

16 Claims, 7 Drawing Sheets



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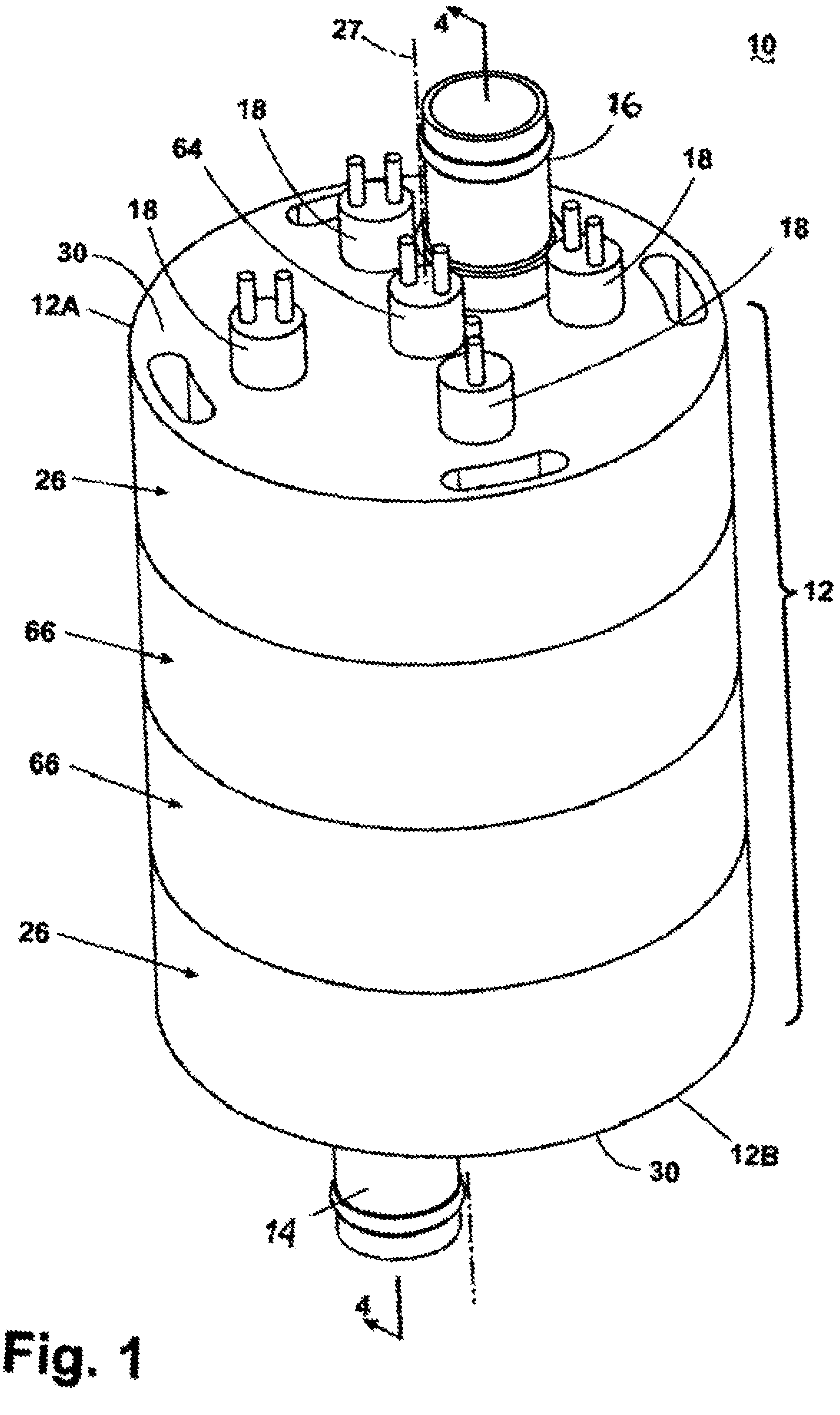

Fig. 1

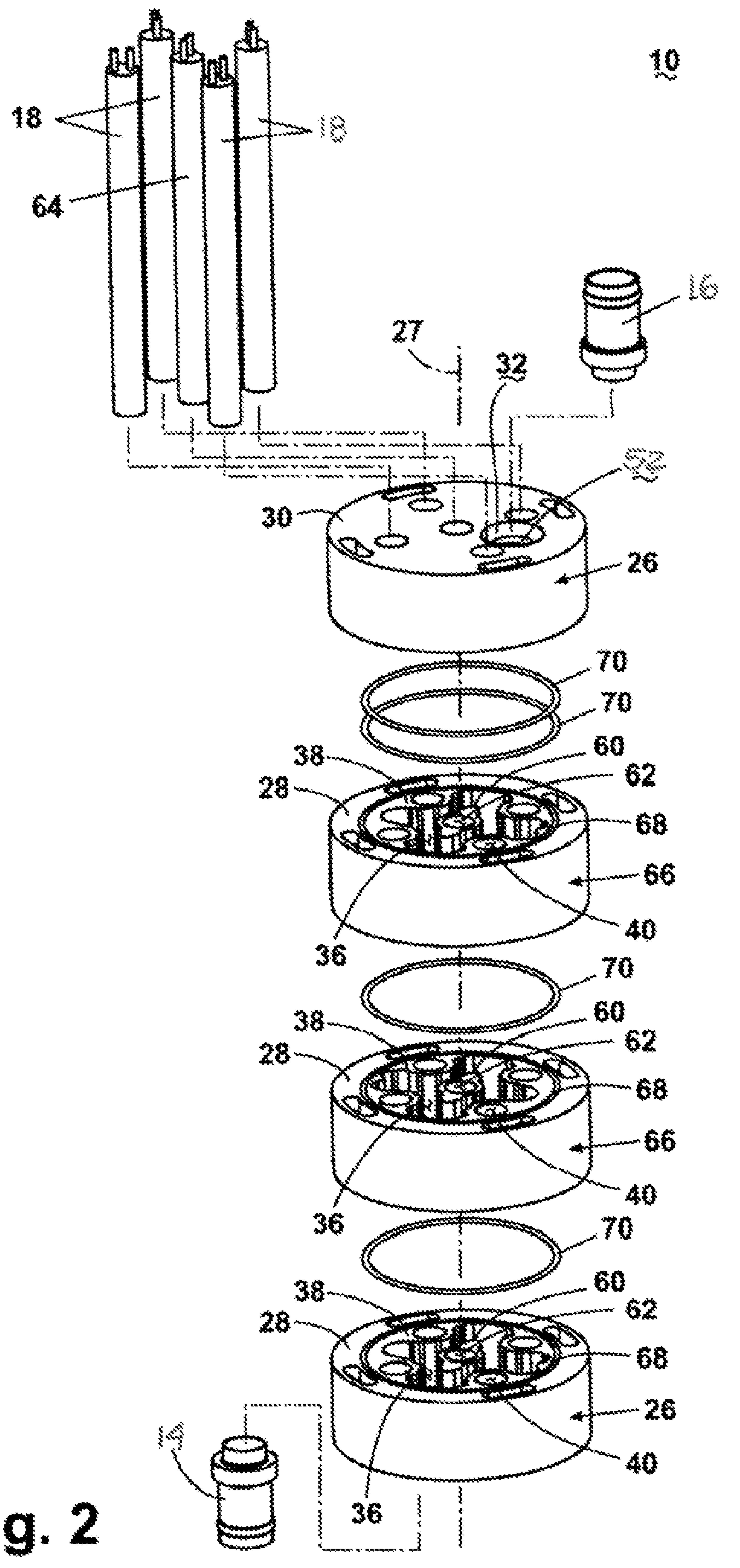

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Fig. 2

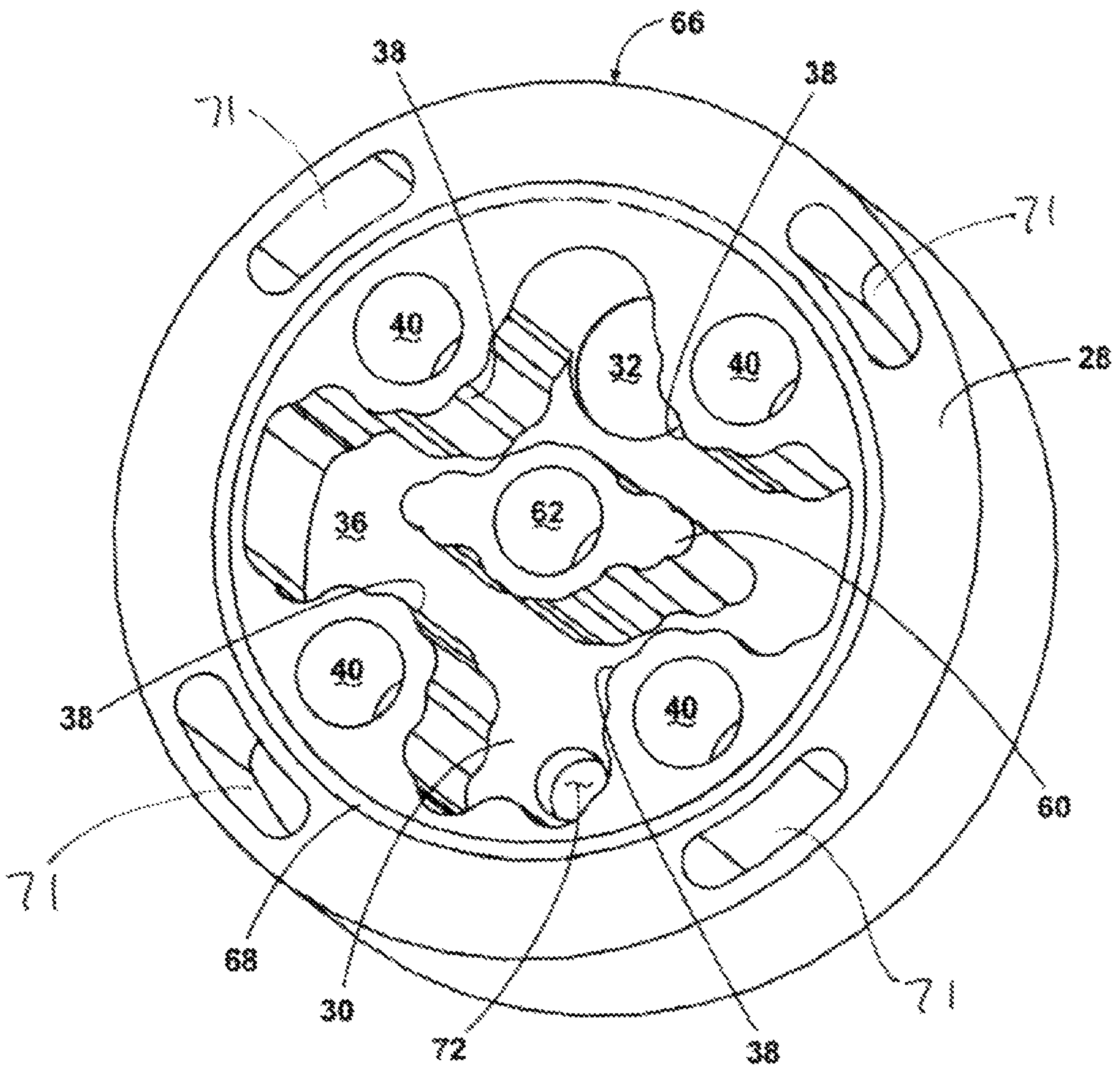

Fig. 3

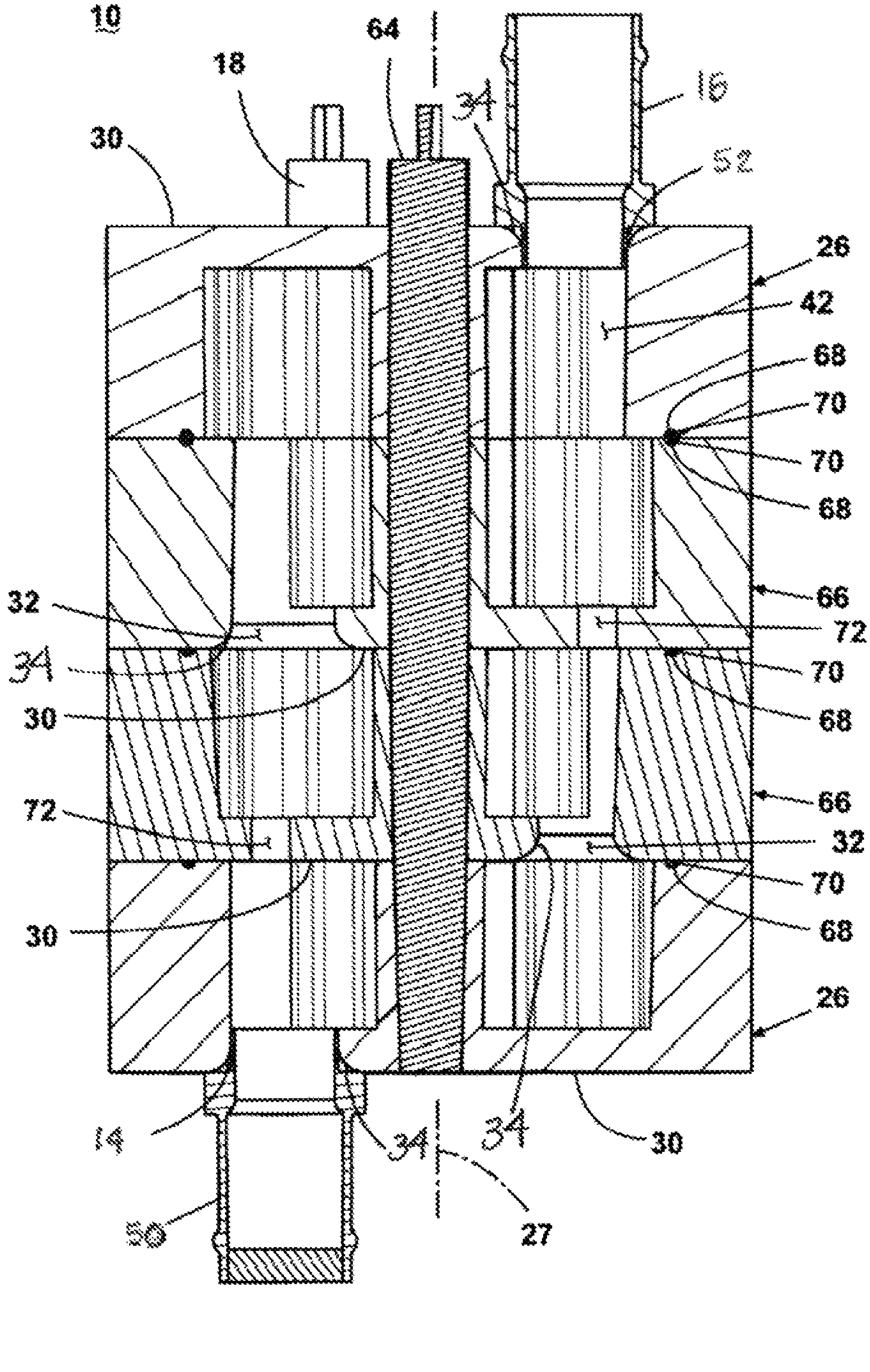
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Fig. 4

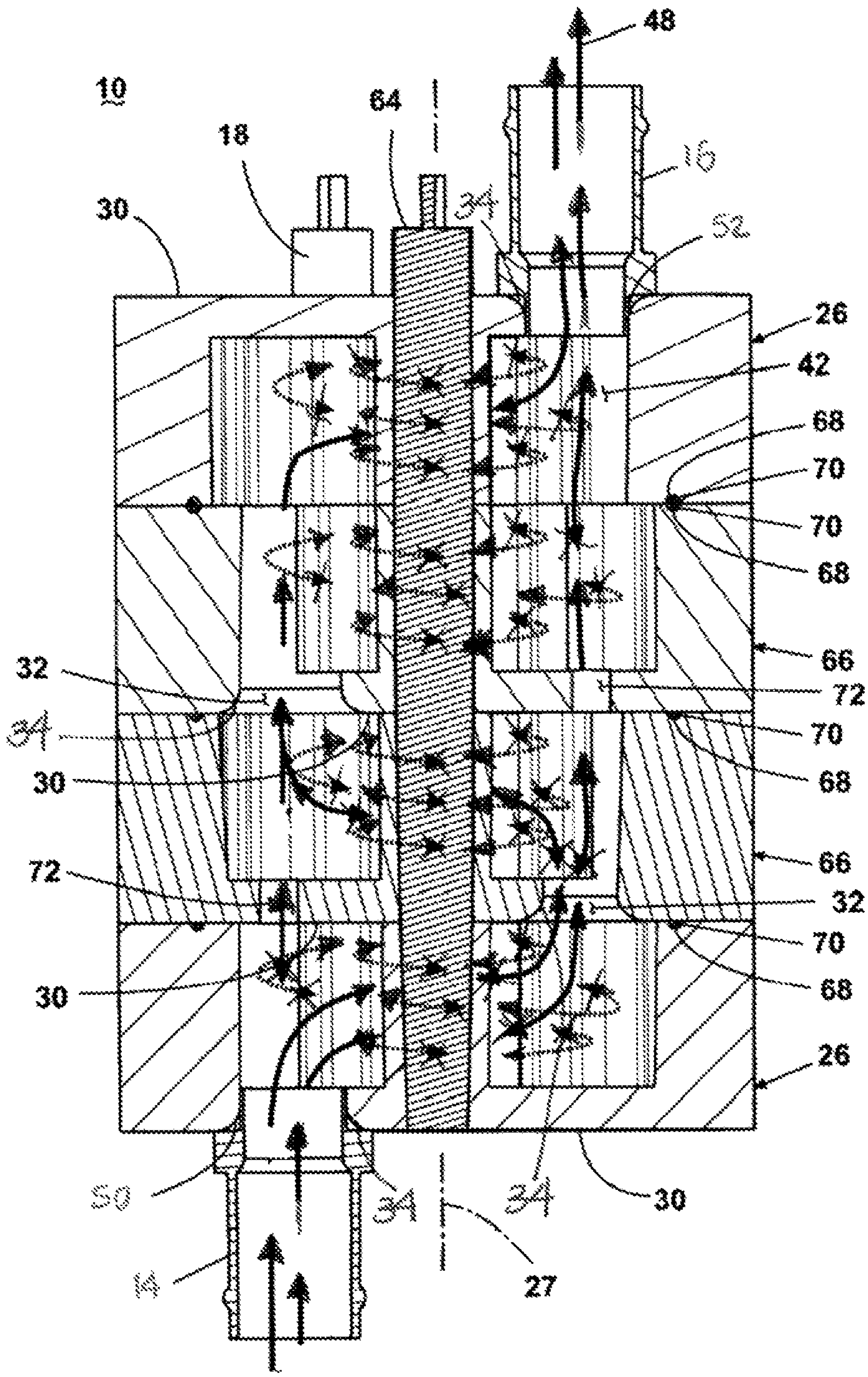
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Fig. 5

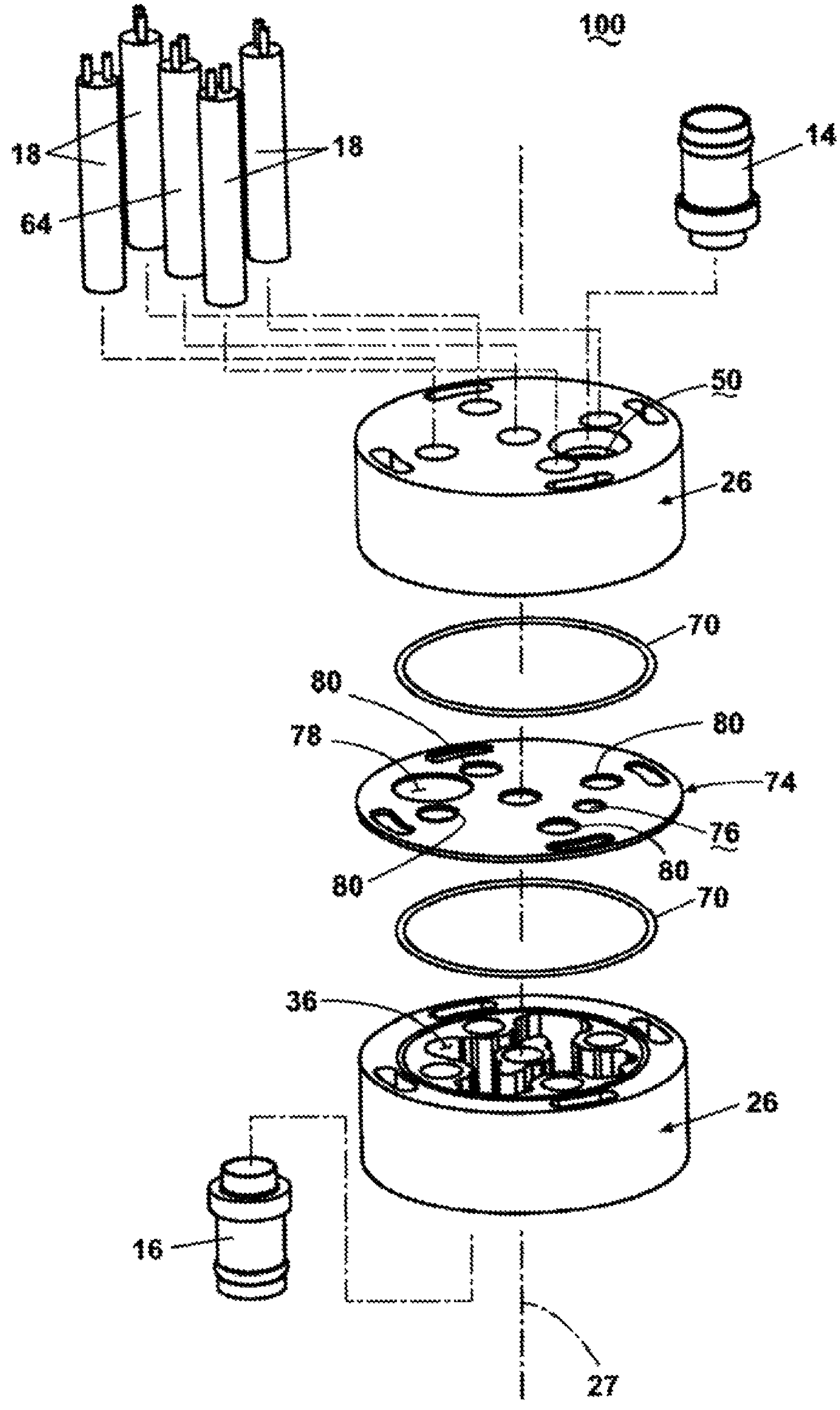

Fig. 6

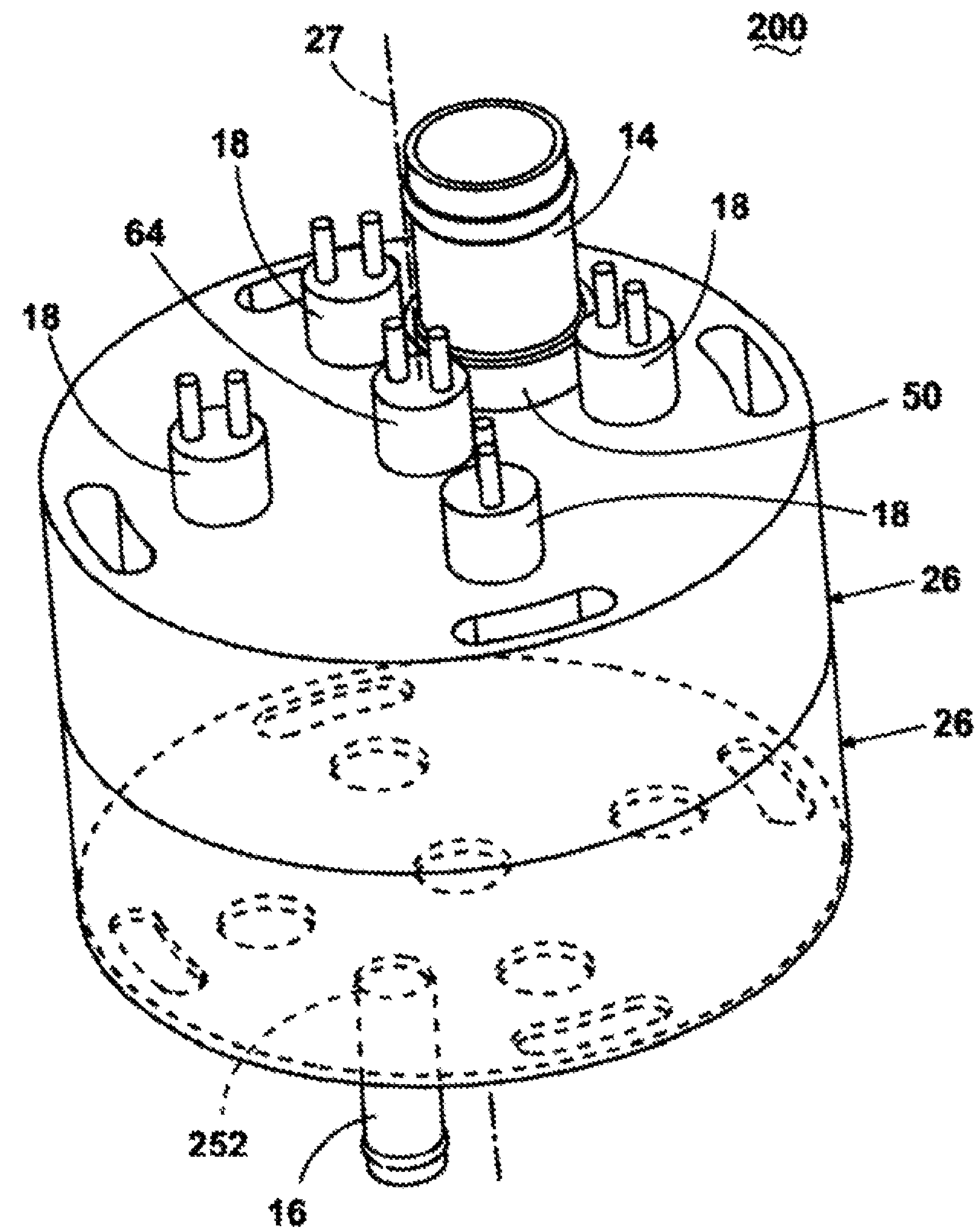

Fig. 7

FLUID PREHEATER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a National Phase application of International Application No. PCT/US2009/052337, filed Jul. 31, 2009, which claims the benefit of U.S. Provisional Application No. 61/086,657, filed Aug. 6, 2008, both of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to devices for preheating fluid.

SUMMARY OF THE INVENTION

In one aspect, a fluid preheater includes a body having an interior wall defining a chamber with an inlet and an outlet. The body has two or segments, each segment having an annular perimeter wall and an end wall with an opening in the end wall and an axial post extending from the end wall within the chamber. A center bore is in the axial post to receive a heater. Lobes extend into the chamber from the perimeter wall of each of the segments, each lobe having a bore. The bores are disposed closer to the chamber than to the exterior of the body. One or more heaters is in the center bore or the one of the bores in the lobes. The heater is not exposed to the chamber. There is at least one baffle in the chamber which will cause turbulence in the flow of fluid through the chamber from the inlet to the outlet to increase the exposure of the fluid to heat from the heater.

In another aspect, a fluid preheater includes a body having an interior wall defining a chamber with an inlet and an outlet. The body has two or segments, each segment having an annular perimeter wall and an end wall with an opening. Each segment has an annular groove on the annular edge of the perimeter wall away from the end wall, where a seal is located for sealing one segment to the next. One or more heaters is in the wall, wherein the heater is not exposed to the chamber. The heater is not exposed to the chamber. There is at least one baffle in the chamber which will cause turbulence in the flow of fluid through the chamber from the inlet to the outlet to increase the exposure of the fluid to heat from the heater.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a perspective view of a fluid preheater according to a first embodiment of the invention.

FIG. **2** is an exploded view of the fluid preheater illustrated in FIG. **1**.

FIG. **3** is a perspective view of a segment of the fluid preheater illustrated in FIG. **1**.

FIG. **4** is a cross-sectional view of the fluid preheater illustrated in FIG. **1** taken along line **4-4**.

FIG. **5** is the cross-sectional view of the fluid preheater shown in FIG. **4**, additionally illustrating a fluid flow path.

FIG. **6** is a perspective view of a fluid preheater according to a second embodiment of the invention.

FIG. **7** is a perspective view of a fluid preheater according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings, several embodiments of the invention are illustrated. In each, a fluid preheater **10** according to the invention comprises a body **12** fluidly coupled with an inlet tube **14** and an outlet tube **16**. The body **12** raises the temperature of a fluid (not shown) that enters through the inlet tube **14** and exits the outlet tube **16** by causing the fluid to linger in the body, thereby increasing the time the fluid remains in contact with the body before it exits. A fluid preheater **10** according to the invention can heat any suitable fluid such as a coolant associated with an engine cooling system, or an isolated fluid supply.

The body **12** defines an interior chamber **42** and comprises at least two body segments **26**. Each body segment **26** is preferably cylindrical, having a longitudinal axis **27** and a circular cross-sectional configuration. The body segment **26** is thus defined in part by an annular perimeter wall **28**, an end wall **30** closing one end but having an opening **32** offset from the longitudinal axis, and the other end being open. The perimeter wall **28** and the end wall **30** thus define an open cavity **36**. Multiple body segments **26** can be stacked to form a body **12** as shown in FIGS. **1** and **2**. Together, the multiple open cavities **36** of adjacent body segments **26** make up the interior chamber **42**. The cavity **36** in each body segment (and thus the interior chamber **42**) can be irregularly shaped, a direct result of the irregular thickness of the perimeter wall **28** show in the drawings. The body segments **26** can be cast of aluminum, although other suitable materials and methods of manufacture are possible.

Referring now to FIG. **3**, the body segment **26** further comprises a plurality of lobes **38** defined by the irregular thickness of the perimeter wall **28** and which extend from the perimeter wall **28** into the cavity **36**. A bore **40** is located in each lobe **38** for receiving a cartridge heater **18** (FIG. **2**). In the embodiment illustrated in FIG. **2**, there are four cartridge heaters **18** shown installed in each of the four bores **40** in the perimeter wall **28**. However, utilizing more or fewer lobes **38**, bores **40**, and cartridge heaters **18** is feasible. It should be noted that the bores **40** are disposed closer to the cavity **36** than to the exterior of the body **12**. This promotes heat transfer to the fluid within the cavity **36** more so than the transfer of heat to the exterior of the body **12**. Exemplary cartridge heaters include those available from Hotset Corporation of Battle Creek, Michigan. Wattage requirements of the cartridge heaters **18** will depend on specific application demands.

The body segment **26** also includes a center axial post **60** extending from the end wall **30** within the cavity **36** and having a center bore **62** aligned with the longitudinal axis **27**. The center bore may be configured to receive a cartridge heater **64** (FIG. **2**).

Referring again to FIGS. **1** and **2**, the cartridge heaters **18**, **64** can be installed through the bores **40**, **60**, which, preferably, have the same shape as the heaters **18**, **64**, such as the cylindrical shape illustrated in the drawings. The heaters **18**, **64** can have electrical leads which can be coupled to a suitable power supply (not shown). Heating the cartridge heaters **18** will cause the perimeter wall **28** to heat through conduction. Fluid passing through the interior chamber **42** absorbs heat from the perimeter wall **28** by various heat transfer mechanisms, including radiation, convention and conduction. The lobes **38** on the interior of the perimeter wall **28** increase the surface area of the interior chamber **42** perimeter, thereby facilitating heat transfer from the perimeter wall **28** to the fluid. Cartridge heater **64** is illustrated as penetrating the end wall **30** through the center bore **62** located in the center of the cavity **36** to provide additional heating of the fluid in the chamber **42**. This cartridge heater **64** can be similarly coupled through electrical leads to the power supply. Further, cartridge heater **64** can be of a difference wattage than that of cartridge heaters **18** such that the fluid preheater **10** can optionally be operated at high or low power through selectable circuits. In other words, one might select only the cartridge heaters **18** or only the cartridge heater **64** or both. As well, it is within the scope of the invention to separately control each cartridge heater **18**, **64** to more finely control the amount of heat transfer to the interior chamber **42**. Other heating elements, such as coil heaters, tubular heaters, and the like can be substituted for or added to the cartridge heaters. As well, it is within the scope of the invention for a hot fluid to be directed through the bores **40** to heat the body **12**.

The fluid preheater **10** comprises at least two body segments **26**, both of which are identical. One or more additional body segments **26** can be utilized also, providing a modular assembly, and adding heating capacity in preselected increments. The additional body segments **26**, defined as interior body segments **66**, are sandwiched between the two end segments **26**. The two end body segments **26** are positioned in a clamshell arrangement, otherwise described as being in minor-image of one another. Multiple interior body segments **66** preferably face the same direction, which by default is also the same direction as one of the end segments **26**. But it is apparent that the interior body segments **66** will face in the direction of one or the other end body segments **26**. In the embodiment illustrated, four body segments **26**, **66** are shown; however more or fewer segments are feasible, with a minimum requirement of two end body segments **26**. The body segments **26** and **66** are generally identical in structure, but for purposes of clarity are numbered differently in this description depending on their location. The end walls of the interior body segments **66** serve as baffles to obstruct the flow of fluid as explained below.

Looking further at FIG. **3**, the body segment **26**, **66** further comprises an annular groove **68** located on the annular edge of the perimeter wall **28**, away from the end wall **30**. A seal **70** is positioned in the groove **68** and is adapted to seal one body segment **26**, **66** to an adjacent one. The seal **70** can be any suitable seal, such as a well known rope seal or gasket, or the body segments **26**, **66** can be sealed by a suitable adhesive. Further, each segment **26**, **66** has slotted bores **71** near the exterior perimeter wall. When the segments are stacked, the slotted bores **71** will be in registry to enable a fastener to secure the segments to each other. A typical fastener can include a bolt and one or more nuts, a rivet, a clamp or a similar conventional device (none of which are shown in the drawings).

With the body segments **26**, **66** thus disposed, the body **12** can be defined as having an inlet end **12**A and an outlet end **12**B. Further, end body segments **26** each include the end wall opening **32**; the opening **32** on the inlet end **12**A is defined as inlet opening **50** and the opening **32** on the outlet end **12**B is defined as outlet opening **52** (FIG. **4**). The inlet opening **50** can fluidly couple the interior chamber **42** with the inlet tube **14** and the outlet opening **52** can fluidly couple the interior chamber **42** with the outlet tube **16**. Further, the transition between the end wall opening **32** and the exterior of the end wall **30** is defined by a radius **34**. It has been found that the shape of the radius **34** is an important characteristic regarding the backpressure and backflow characteristics between cavities **36**.

Referring to FIG. **4**, the end body segments **26** and any interior segments **66** that make up the fluid preheater assembly **10** are oriented out of registry or phase with one another; meaning that the openings **32** in the end walls **30** of adjacent body segments **26**, **66** are not in axial alignment. This is accomplished by positioning the adjacent body segments **26**, **66** rotated relative to one another. In the embodiment illustrated, for example, because the body segments **26**, **66** have four lobes **38**, bores **40**, and perimeter cartridge heaters **18**, the segments **26**, **66** are rotated in increments of 90° relative to the adjacent body segment **26**, **66**. By the nature of the above described mirror-image positioning, the two end body segments **26** are positioned with the inlet opening **50** and outlet opening **52** rotated 180° relative to one another. Any additional included interior body segments **66** are positioned with the end wall opening **32** rotated one of 90° or 180° relative to the adjacent body segment **26**, **66**. In this way, the inlet opening **50**, interior end wall openings **32**, and the outlet opening **52** are out of phase with the adjacent body segment **26**, **66**. It is feasible to include more or fewer lobes **38**, bores **40**, and cartridge heaters **18**, which would respectively change the angle at which the body segments **26**, **66** are rotated relative to one another. The purpose of the misalignment between adjacent body segments **26**, **66** is to cause fluid to travel a greater distance within each cavity **36**, thereby causing the fluid to linger in the interior chamber **42** longer than it would if passing directly from the inlet opening **50** to the outlet opening **52**. This increases the time the fluid dwells in the interior cavity **42**, thereby increasing the exposure to the heat provided by the cartridge heaters **18**.

Referring again to FIG. **3**, interior body segments **66**, otherwise identical to body segments **26**, can also include a weep hole **72**, which can be machined as a secondary operation. The weep hole **72** extends through the end wall **30** and is positioned 180° opposite the end wall opening **32**. The weep hole **72** functions to allow a preset amount of fluid flow directly from one cavity **36** to the next adjacent cavity **36**. This allows a "high speed front" to form which causes the main fluid volume to be restricted before it can cross to the next adjacent cavity **36**. This results in the fluid turning relative to the motion of the front, remixing in the cavity **36** below the front within the cavity **36**, thereby increasing the dwell time of the fluid in the cavity **36** and promoting the exposure to the heated surface. Further, the weep hole **72** can be calibrated for different fluid viscosities as needed through shape or size adjustment.

FIG. **5** illustrates the fluid flow through the interior chamber **42** from the inlet opening **50** to the outlet opening **52**. Within the interior chamber **42**, the fluid can travel a twisted, circuitous path **48** created by the configuration of the interior chamber **42**, the offsetting of the end wall openings **32**, the weep hole **72**, and thermal gradients within the fluid. Additionally, the end walls **30** act as baffles to increase turbulence and further move the fluid through the circuitous path **48**.

Referring to FIG. **6**, in an alternate embodiment where similar elements from the first embodiment are labeled with the same reference numerals, an alternate fluid preheater **100** is illustrated. The preheater **100** comprises two end body segments **26**, an inlet opening **50**, an outlet opening **52** (not shown), and can be fluidly coupled to an inlet tube **14** and an outlet tube **16**. The preheater **100** further includes a baffle plate **74**, defined by a flat metal disc. The baffle plate **74** includes bores **80** through which the cartridge heaters **18** can be inserted, a weep hole **76**, and an opening **78**, all similar to those located on the end wall **30** of the segment **26**. The baffle plate **74** is sandwiched between the two oppositely facing end body segments **26**; seals **70** are positioned between the baffle plate **74** and each end body segment **26** to seal the body segments **26** and baffle plate **74**. The preheater **100** functions similarly to that of the first embodiment, the baffle plate **74** providing the means to cause the fluid to linger in the interior chamber **42** (FIG. **1**) longer.

Referring to FIG. **7**, in an alternate embodiment where similar elements from the first embodiment are labeled with the same reference numerals, an alternate fluid preheater assembly **200** is illustrated. The preheater **200** comprises two end body segments **26**, an inlet opening **50**, an outlet opening **252**, and can be fluidly coupled to an inlet tube **14** and an outlet tube **16**. The end body segments **26** are assembled in a clamshell relationship, as described above. The preheater **200** further includes a means to cause fluid passing through the interior chamber **42** from the inlet opening **50** to the outlet opening **252** to linger in the interior chamber **42** longer than it would if passing directly from the inlet opening **50** to the outlet opening **252**. One means to cause the fluid to linger in the interior chamber **42** is to size the outlet opening **252** smaller in diameter than the inlet opening **50**. Another means to cause the fluid to linger in the interior chamber **42** is to include a body that is configured to create a cyclone motion of fluid within the interior chamber **42**. This could be accomplished in a variety of methods well known in the art. One example of which is to configure the lobes **38** on the perimeter wall **28** in such a way as to induce a cyclonic motion of the fluid as it passes through the cavities **36** and interior chamber **42**. Any of these means will cause the fluid to travel a twisted, circuitous path, increasing the time the fluid dwells in the heating cavity **42**, and thereby increasing the exposure to the heat provided by the cartridge heaters **18**.

For example, in use, the inlet tube **14** can be coupled with a radiator or storage system and pump to thereby utilize coolant in the fluid preheater **10**, **100**, **200**. The outlet tube **16** can be coupled with a device for which heating is desired, such as a water jacket, reservoir, and the like, surrounding a battery. Flow of heated fluid from the preheater **10**, **100**, **200** through the heating device could then heat the battery. The cartridge heaters **18**, **64** can be controlled through a thermal sensor and suitable control circuitry, such as a microprocessor-based controller, to heat the fluid to a selected temperature appropriate for heating of the fluid.

Alternative heat transfer systems can comprise redirected bypass systems for reheating the fluid, recirculation chamber designs, including independent circulation chambers, and flow slopes to create predictable high and low pressure paths and the/or reduce fluid velocities. Vortex principles can also be utilized to rotate the fluid to increase heated surface velocities, thereby increasing permissible watt densities before boiling occurs.

The fluid preheater is a high wattage heating assembly packaged in a small volume device which can be readily incorporated into a system requiring a heat source. The design of the preheater provides a very low pressure drop at both low and high flow rates. Increased flow and reduced pump sizing can be realized through utilizing fluid heat expansion techniques and optimizing chamber designs, including heated flow redirectors. The interior chamber can be surface coated to seal the surface of the chamber and reduce drag on the fluid.

Microsized transducers (not shown) mounted in the interior chamber **42** can be utilized to create a stand alone heater control system by modeling and creating a computation model using actual fluid variables to control and protect heaters and heating elements from failure. Variables to be measured can include incoming fluid temperature, outgoing fluid temperature, surface pressure in the interior chamber, and a flow rate.

Air chambers can be cast in the preheater housing to provide thermal barriers, thereby reducing the outside temperature of the housing. Ceramic epoxies, doped with fiberglass and Kevlar fibers or other insulation materials appropriate to the temperatures anticipated can reduce the heat transfer from the exterior of the housing, thereby providing increased efficiency of heat transfer to the interior chamber **42**. Heating elements can be installed in the preheater housing by boring receptacles to lock the heating elements in place, and provide more surface area for heat transfer from the heating element to the housing. Heaters can also be cast into the housing, or can be configured to be replaceable.

While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reasonable variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims.

What is claimed is:

1. A fluid preheater comprising:

a body having an interior wall defining a chamber and having an inlet and an outlet, the body having at least two segments;

each segment having an annular perimeter wall and an end wall with an opening in the end wall and an axial post extending from the end wall within the chamber with a center bore in the axial post to receive a heater;

lobes extending into the chamber from the perimeter wall of each of the at least two segments, each lobe having a bore wherein the bores are disposed closer to the chamber than to the exterior of the body;

at least one heater in one of the center bore or the bores in the lobes, wherein the at least one heater is not exposed to the chamber; and

at least one baffle in the chamber;

whereby the at least one baffle will cause turbulence in the flow of fluid through the chamber from the inlet to the outlet to increase the exposure of the fluid to heat from the at least one heater.

2. A fluid preheater according to claim **1** wherein the at least two segments are identical.

3. A fluid preheater according to claim **1** wherein the at least one heater is a cartridge heater.

4. The fluid heater of claim **1** wherein the end wall forms the at least one baffle.

5. The fluid heater of claim **1** wherein the openings in the end walls of adjacent segments are not in registry.

6. The fluid heater of claim **1** wherein the body includes four segments and the end segments are disposed in a clamshell relationship and the interior segments are positioned like one of the end segments.

7. A fluid preheater according to claim **6** wherein at least one of the interior segments has an additional opening.

8. A fluid preheater comprising:

a body having an interior wall defining a chamber and having an inlet and an outlet, the body having at least two segments, each segment having an annular perimeter wall and an end wall with an opening;

wherein each segment has an annular groove on the annular edge of the perimeter wall away from the end wall, and wherein a seal is located for sealing one segment to the next;

at least one heater in the wall, wherein the heater is not exposed to the chamber; and

at least one baffle in the chamber;

whereby the at least one baffle will cause turbulence in the flow of fluid through the chamber from the inlet to the outlet to increase the exposure of the fluid to heat from the at least one heater.

9. A fluid preheater according to claim **8** wherein the end wall and the annular perimeter wall define an open cavity that forms the chamber.

10. A fluid preheater according to claim **8** wherein each segment comprises multiple bores in the perimeter wall each to receive a heater.

11. A fluid preheater according to claim **8** wherein the openings in the end walls of adjacent segments are not in registry.

12. A fluid preheater according to claim **8** wherein the body includes four segments and the end segments are disposed in a clamshell relationship and the interior segments are positioned like one of the end segments.

13. A fluid preheater according to claim **12** wherein at least one of the interior segments has an additional opening.

14. The fluid heater of claim **8** wherein the end wall forms the at least one baffle.

15. The fluid heater of claim **8** wherein the at least two segments are identical.

16. A fluid preheater according to claim **8** wherein the at least one heater is a cartridge heater.

* * * * *